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Thomas J. Klitgaard

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The Context for Innovation in Japan: Comparative Competitive Aspects and Some Practical Comments

*Thomas J. Klitgaard**

Would it surprise you to learn that in a recent survey three-fourths of Chicago manufacturers believed that Japan leads the United States in product innovation? Or that there is a greater relationship between R&D expenditures in Japan and patent applications than in the United States? Or, perhaps more startlingly, that Japanese-origin U. S. patents are now being cited more often, and with increasing frequency, in the U. S. Patent Office than patents from other countries, including the United States—with patents by Americans being cited second and Canadians third?

Or would it further surprise you to learn that from its position in the 1960s as an economy that relied extensively on the receipt and modification of externally developed technology, Japan has now emerged as an economy where many firms define the technological frontiers in their industries? Or that the ratio of the value of Japan's technology exports to the value of technology imports has increased from roughly forty percent in fiscal 1985 to roughly one hundred percent in 1989—resulting in a virtual equality in value between exports and imports of technology.

Lest we think narrowly, do you believe that innovation is limited only to science or technology? Or would you accept that it appears in all phases of human activity, from the shop floor to how this law review is published? What is the key ingredient for innovation and what is its context in Japan? In virtually every area, we can observe the great strides made by the Japanese in the last fifty years. How is this happening? More importantly, why is this happening?

To find the answers, we turn briefly to what Japan looked like 140 years ago. Then to its relative balance of resources in 1941 when Japan committed itself to a war with the United States and its allies. Then to its reputation, in some areas, for imitation. And, finally, to the amazing results of its financial and economic strategies during the past half century. To put all this in perspective, we start with some relevant observations:

•“In 1853 Admiral Perry of the United States steamed into Japan, guns loaded, and forcefully broke Japan's long isolation. By 1868 Ja-

* Mr. Thomas J. Klitgaard is Senior Vice President and General Counsel, Sega of America, Inc. The views expressed are solely those of the author.

pan was forced to either be the whipping boy in [its] international trade agreements or adopt a Western modus operandi. Soon what had begun with Western coercion to trade became a massive Occidentalizing movement.”¹

•“During the last week of August [1941], he [Colonel Iwakuro, who had worked on the Draft Understanding with the United States to avoid war] attended a liaison conference [with the Navy], where he contrasted the alarming differences between American and Japanese war potential. In steel, he said, the ratio was 20 to 1; oil more than 100 to 1; coal 10 to 1; planes 5 to 1; shipping 2 to 1; labor force 5 to 1. The overall potential was 10 to 1. At such odds, Japan could not possibly win, despite *Yamato damashii*—the spirit of Japan. For once his listeners were impressed and Tojo ordered Iwakuro to make a written report of everything he had just said.

“The following day Iwakuro arrived at the War Minister’s office to discuss the report but was summarily told by Tojo that he was being transferred to a unit in Cambodia. ‘You need not submit the notes in writing I requested yesterday.’

“As Iwakuro was boarding the train for the first leg of the trip south, he told his friends, ‘So many of you have come to bid me farewell, but when I return to Tokyo—if I survive—I’m afraid I shall find myself alone in the ruins of Tokyo station.’”²

•“The unpreparedness on the part of the [Japanese] Navy [in 1942 to protect commercial shipping from destruction by American submarines] was the result of a combination of tradition and of reluctance to change in the Imperial Navy, which adopted all things English so readily that the Naval Academy at Etajima became a replica of Dartmouth. Bricks were brought from England, and a lock of Lord Nelson’s hair enshrined in Memorial Hall. Imitation extended to the galley, and once a day a Western meal, complete with knives, forks and spoons, was served throughout the Navy. In battle, Japanese captains followed British tradition by going down with their sinking ship. More important, the Japanese inherited the British aversion to wage war on commercial vessels. But such a policy could succeed only if an enemy shared it. The Germans did not, and when their submarines launched devastating raids on British merchantmen in World War I, the British had been forced to retaliate in kind as well as create an efficient antisubmarine service.”³ [However, in this instance the Japanese did not follow the British example.]

•“As recently as 1960, Japan and East Asia together accounted for four percent of world GNP, while the United States, Canada, and Mexico represented 37 percent. Today both groups have about the same share of the world’s GNP (some 24 percent each), but, with

¹ R. E. Watts, *Briefing the American Negotiator in Japan*, 16 INT’L LAW 597, 599 (1982).

² JOHN TOLAND, *THE RISING SUN* 106-07 (Random House 1970).

³ *Id.* at 542.

more than half the world's economic growth taking place in Asia in the 1990s, the economies of North America and Europe will progressively become relatively smaller."⁴

•“Perceptive Westerners . . . read daily that Japan has been badly damaged by a terrible economic slump, yet the evidence tells a different story. What are they to make, for instance, of the yen's conspicuous strength? In the last five years, it has risen nearly 40 percent against the U.S. dollar. Meanwhile, Japan's exports have risen 41 percent, giving Japan a current account surplus of \$197 billion in 1994. . . . [H]ow can a country be an economic has-been if it boasts one of the strongest currencies in the world while it racks up the largest trade surpluses ever recorded?”⁵

“[T]he Japanese economy has emerged from the early 1990s stronger than ever. . . . [H]ere are a few facts:

— Between 1989 and 1993, Japan rose from sixth in the world in per capita income to a close second, behind Switzerland.

— Japan's per capita income is now more than forty percent higher than America's.

— According to Deutsche Bank, Japan in 1993 passed the United States to become the world's biggest manufacturing economy.

“[O]verall, the Japanese clearly now enjoy one of the highest standards of living in the world. This is evident in their world-beating life expectancy rates, which have increased by nine years since 1964 and now surpass American rates by about three years.”⁶

•“Japan in 1993 accounted for an astonishing 56 percent of the developed world's total net savings. By contrast, the U.S. share was just five percent. The implications of these figures are enormous. In foreign direct investment . . . Japan's outflows have increased fivefold in the last ten years”⁷

•“The MOF [Japan Ministry of Finance] . . . led the Japanese establishment in eschewing direct investment in Japan by foreign capitalists. Thus the MOF violated one of the most cherished principles of Western economics, that unrestricted transfers of capital across borders serve to boost efficiency in recipient countries. The Japanese . . . were influenced in particular by the slow deaths of the Chinese and Ottoman empires in the latter decades of the nineteenth century. Both had thrown themselves open to foreign capital, which in the Japanese view had decapitated these once-proud empires and led to corruption and demoralization.”⁸

⁴ Kishore Mahbubani, *The Pacific Way*, 74 FOREIGN AFF. 100, 100-1 (1995).

⁵ Eamonn Fingleton, *Japan's Invisible Leviathan*, 74 FOREIGN AFF. 69, 69 (1995).

⁶ *Id.* at 81.

⁷ *Id.* at 82.

⁸ *Id.* at 83-84.

“Over the past 40 years, Japanese companies have gone through a cycle of boom and bust, caused by their tendency to pursue every strategy to the maximum and for every company to pursue the same strategy at the same time. As a consequence, no company gains [a] permanent advantage against its domestic competitors. As an industry, however, Japanese companies together can have substantial advantages over their foreign competitors. In one industry after another, Japanese companies overwhelmed their foreign rivals with a strategic surge that looks from the outside like a well-planned Japanese conspiracy but in practice is simply a group of companies in the same industry swarming to the same strategy.”⁹

“High productivity . . . flows chiefly from the ability of managers to invent new and ever more efficient ways of making products and from engineers’ proficiency in designing products that are easy to make.

“Whether in the food industry in the U.S. or the auto industry in Japan, managers and engineers do not arrive at these innovations because they are smarter, work harder, or have a better education than their peers. Rather, they do so because they must. They are subjected to intense global competition, where constantly pushing the boundaries of productivity is the price of entry—and of survival.”¹⁰

“Traditional explanations for Japanese product development advantages have dwelt on expenditures for R&D and number of patent applications. More recent explanations have centered on time as a competitive advantage, supported by MITI and the *keiretsu* and discriminatory practices by the Japanese. The Japanese develop and introduce new products and processes much faster and more economically than the Americans. Their time advantage probably derives from a highly developed subcontractor network, the overlapping of various stages in product design, the excellent communications between functional departments, and the ability to build on advanced Western technology.”¹¹

“Surveys of large manufacturing companies during the 1980s indicate that Japanese firms first reduced nonlabor costs when business deteriorates, while American firms usually turn first to labor costs. American firms lay off workers in order to reduce labor costs while Japanese firms tend to reduce overtime, transfer employees to other shops, departments, or affiliated firms. Japanese firms also create new subsidiaries to absorb redundant labor.

“Japanese workers receive about twice as much on-the-job training and about four times as much firm-specific training as American

⁹ George Stalk, Jr., and Alan M. Webber, *Japan's Dark Side of Time*, HARV. BUS. REV., July/Aug. 1993, at 93.

¹⁰ William W. Lewis et al., *The Secret to Competitiveness—Competition*, MCKINSEY Q. Sept. 22, 1993, at 29.

¹¹ Bernard J. Keys et al., *The Japanese Management Theory Jungle-Revisited*, 20 S. MGMT. ASSOC. J. MGMT. 373 (June 1994).

workers. Further, firm-specific experience has a greater impact on earnings than general experience in Japan, while the opposite pattern prevails in the United States.”¹²

•“The Pacific community will be a completely new creation. It will not be an Asian community, nor will it be an American community. If the Pacific has emerged as the most dynamic region of the world, it is because it has drawn on the best practices and values from many rich civilizations, Asian and Western. If this fusion continues to work, there could be explosive creativity on a scale never seen before.

“Some explosions have already occurred. Japan provides the best example. Culturally, it remains quintessentially Japanese, but its civil administration (with arguably the most powerful Westernized bureaucracy in the world), business, science, and technology are among the best. It has modernized and is no longer a feudal society. Several key imperial ceremonies are conducted in European coattails. But there is no doubt that the Japanese remain Japanese. Their homes are Japanese. Their souls are Japanese. Although many Japanese teenagers look like their European or North American counterparts, their values, though changing, remain fundamentally Japanese . . .

“To many, this is an economic and industrial miracle. But this success is due neither to Japanese culture nor to Western methods; it is the result of the combination of both. In the long run, American society will do as well as Japan when it undergoes a similar osmosis, absorbing the best of Asian civilization.”¹³

•“The President’s Commission on Industrial Competitiveness (1985) defines U.S. competitiveness as the degree to which the United States can, *under free and fair market conditions*, produce goods and services that meet the test of international markets while simultaneously maintaining or expanding the real income of its citizens.

“Numerous studies have shown the importance of a nation’s innovative ability as a foundation for future competitiveness in international trade. A nation’s product and process innovations have become increasingly critical prerequisites for the success of its firms in global competition.”¹⁴

•“Patent data . . . cast some concern over future U.S. competitiveness. About 45 percent of new U.S. patents currently are being granted to foreigners indicating deep patent penetration by foreign firms. About 20 percent of all U.S. patents granted in 1991 were

¹² Marina N. Whitman, *Flexible Markets, Flexible Firms*, AM. ENTERPRISE, May/June 1994, at 28.

¹³ Mahbubani, *supra* note 4, at 107.

¹⁴ Masaaki Kotabe & Eli P. Cox III, *Assessment of Shifting Global Competitiveness: Patent Applications and Grants in Four Major Trading Countries: U.S., U.K., Japan and West Germany*, 36 BUS. HORIZONS (School of Business at Indiana University) 57 (Jan. 1993) (emphasis added).

awarded to the Japanese. In fact, the top four companies receiving U.S. patents in 1991 were all Japanese firms; Toshiba, Hitachi, Canon and Mitsubishi Electric. On the other hand, only 14 percent of Japanese patents were held by foreigners and only 7 percent of all Japanese patents granted in 1989 were awarded to U.S. companies.”¹⁵

I. INNOVATION - THE CALL OF OPPORTUNITY

Innovation, like opportunity, is measured by the occasion. It is the response to circumstance—usually one of great need or great peril. I am reminded of a famous poem by Edward Sill that goes like this:

“This I beheld, or dreamed it in a dream:—

There spread a cloud of dust along a plain;
And underneath the cloud, or in it, raged
A furious battle, and men yelled, and swords
Shocked upon swords and shields. A prince's banner
Wavered, then staggered backward, hemmed by foes.

“A craven hung along the battle's edge,
And thought, “Had I a sword of keener steel—
That blue blade that the king's son bears-but this
Blunt thing!”-he snapped and flung it from his hand.

And lowering crept away and left the field.
“Then came the king's son, wounded, sore bestead,
And weaponless, and saw the broken sword,
Hilt-buried in the dry and trodden sand,
And ran and snatched it, and with battle-shout
Lifted afresh he hewed his enemy down,
And saved a great cause that heroic day.”

(*Opportunity*, by Edward R. Sill)

Was the king's son imitative? Innovative? Inventive? Was he just lucky? Or were his actions formed, or forced, by competition? Where does the answer lie?

II. THE COMMON, YET UNCOMMON, VIEW

In thinking about innovation, I had the good fortune to talk with a number of friends, business acquaintances, and others about their views on innovation in the modern world—specifically, in Japan. Almost everyone tended to think in terms of technology, or to the availability of special financial resources or protectionism. From my perspective, innovation flows from a combination of factors—the most critical of which is necessity. But before we reach necessity, we need to consider more

¹⁵ *Id.*

about the subject of innovation itself, and touch upon one little-discussed strategy for innovation.

III. A FEW THOUGHTS ON INNOVATION

One might ask, what is innovation? It lies somewhere on a spectrum from imitation to pure invention. It obviously is not mere copying.

One might also ask, where does innovation occur? And is not the answer that it occurs everywhere, in every circumstance where someone does something a little better than the time before? Oh, There are no Nobel prizes for this type of innovation, but perhaps the person who first measured the angles of the sun's rays against the horizon was as much an innovator as the inventor of the cathode tube.

Indeed, one of the paradigms of innovation in Japan is the fact that there have been relatively few Nobel prizes awarded to Japanese citizens. In the entire period from the beginning of these awards through 1994, only three Japanese were so recognized in physics. Yukawa Hideki received the award in physics in 1949, some forty-eight years after the first Nobel laureate was awarded in 1901. Only two other Japanese have received a nobel laureate in physics, as compared to fifty-seven Americans and nineteen Germans.

Likewise, in chemistry, only one Japanese, Fukui Kenichi, who was recognized as a Nobel laureate in 1981, has received the award.

Finally, in economic science, which was established in 1969 as a new category for the award, no Japanese has ever been selected as a Nobel laureate. Here twenty-five of the thirty-eight awards have gone to Americans, with a smattering to British, French, Russian, Dutch, and Norwegian economists. Indeed, the list of Nobel laureates in the scientific and economic fields is conspicuous by the absence of nearly anyone from Asia, Africa, or Latin America.

What does all this mean? Does it mean there is no innovation in Japan, or that the innovation is so minor that it can hardly be counted on the world stage? Or that innovation occurs in a different context and marches to a different drummer?

When we read the headlines, we learn of startling economic successes in Japan, with the yen daily becoming stronger than the dollar and Old-World currencies. We learn, more importantly, that the greatest innovations in social conditions and in modern economics are occurring in Asia, with the gradual melding of Communism and capitalism in China and, specifically, in Hong Kong.

We also learn that the crucible from which innovation comes is built on change. Change usually follows from necessity. Necessity in turn follows from competition to survive.

It is in this context that we need to consider the comparative aspects for innovation in Japan, the United States and Canada. A person looking at the history of innovation in the last century will see that a

few inventions triggered a dislocation of capital, largely leading to an equalizing of opportunity in other geographic regions over time. This will continue to occur as capital changes — and is changing — from natural resources and money, and entrenched political power, to intellectual power. And this is where we are going tomorrow.

A. *A Strategy of Innovation*

We should not be caught up in the past, as archaeologists might, but instead should be thinking of the future as strategists. I would submit that some of Japan's current strategies in high technology areas are implicitly built around the theories long ago developed by Alfred Thayer Mahan, who was our foremost naval philosopher at the turn of the century and whose theories guided a whole generation or two of thinkers on global power.

Alfred Thayer Mahan was a captain in the United States Navy who taught at the Naval War College. He developed the theory of the heartland and the rimland—it was his thought that whoever controlled the rimland controlled the heartland. In historical perspective, this meant that whoever controlled access to the sea controlled the economies, and to some extent the destinies, of the countries lying beyond the sea. This explains, in a sense, the great passion of the Czars for warm water access, which was still of concern as recently as the last twenty years in terms of Russia's relationship with Iran and desire for Iran's warm water ports.

In the context of innovation, the heartland is the vast body of technology that is being developed daily by intelligent and innovative people in all parts of the world. The rimland will be the legal systems that control access to this technology. And here, you see the context for Japanese innovation in not only improving and developing its own products, but in seeking control of the rimland through astute use of the patent process. Let me explain by citing a recent example. A recent headline in the Japanese press proclaimed: "Japan Ranks 1st Among Foreign Patent Winners." The article went on to point out a continuous phenomenon with respect to patents issued by the United States Patent Office:

More than 20 percent of patents issued by the U.S. Patent and Trademark Office in fiscal 1994 went to Japan, making Japan the largest foreign patent winner in the year to last September, according to the Office's statistics released Monday. Japan was granted 23,764 patents, more than 50 percent of those issued to foreign applicants and up from 22,942 patents in the previous fiscal year. In fiscal 1994, the Office issued a total of 113,268 patents, of which 64,119 went to U.S. inventors and 49,149 to foreigners.¹⁶

¹⁶ *Japan Ranks 1st Among Foreign Patent Winners*, JIJI PRESS TICKER SERVICE, Jan. 31,

A number of commentators have pointed out that Japanese companies have a practice of surrounding basic patents with improvement patents, which limit the use of the basic patent and which in effect give the Japanese companies control over the rimland. With this control, the companies holding the improvement patents are able to obtain licenses for the basic patents at far less cost, and are also able to charge a toll for use of the improvements.

B. A Necessity for Innovation

In addition to this strategy, one context for innovation in Japan is the recognition by the Japanese that their country is resource-poor. It has virtually none of the natural resources necessary to sustain a modern industrial society. It is for this reason that Japan is taking a lead in developing the infrastructures of other countries in Asia which are not resource-poor. Indeed, it has been estimated that Japan's development assistance has increased to the point where Japan now slightly outspends the United States. A decade ago, the United States outspent Japan two to one in development aid. According to a recent article in *Foreign Affairs* magazine, there is some indication that Japan now accounts for fifteen to twenty percent of the entire government budgets of almost every East Asian country. In terms of innovation, if innovation means creating a condition that will allow for commercial success or the development of new products and services, this means that Japan is continuing to break away from any thought of isolation and is laying the groundwork for an explosion in markets in Asia.

The explosion in markets in Asia will have the same impact on innovation as the Industrial Revolution, because it will force nations to adapt or see their present advantages evaporate. In the Industrial Revolution, the battle was for mechanical improvements. In the Asian revolution the battle is for technology and social change. Japan can hardly ignore the change, because it sits right on Asia's doorstep at the crossroads of the emerging new Asian world. How like Greece, Rome, and Constantinople!

Recall that it was about 140 years ago that Japan was an isolated country. For over 300 years its only contact with the outside was through an occasional whaling ship or missionary, neither being particularly well-received. But Commodore Perry's arrival created a necessity to change.

In the United States and Canada, we have learned that necessity can produce great technological and social leaps. Those of us over fifty years old recall the shock caused by the news of Sputnik. It will be similarly traumatic to witness the explosive growth of the Asian Rim, with countries emerging as economic and social powers that were

barely a name on the map a generation ago. How will North America respond to the trauma? Will it go into denial? Or will it take the risk to spend its capital to maintain a competitive advantage? Will it be willing to innovate in Asia, on Asia's terms?

Innovation can come to Asia in many forms from our North American civilization. For example, from competing with France to provide the principles for a legal system in Cambodia, to the establishment of workable and practical rules of intellectual property protection in the region. We need to recognize that we no longer compete through sheer power but must compete in an intellectual way through technology, law, and human development.

C. *A Future Context For Innovation*

A true understanding of the future context for innovation in Japan, the United States, and Canada can be drawn from a thoughtful reflection on how these countries are approaching — and should approach — investment and other relationships with the emerging nations on the Asian rim.

I believe that Kishore Mahbubani, the Permanent Secretary of Singapore's Ministry of Foreign Affairs, and the Dean of the Civil Service College in Singapore, summed up best the comparative context for innovation in Japan, the United States, and Canada when he recently wrote:

The significant difference between the 21st century and the preceding centuries is that there will be three centers of world power (Europe, North America and East Asia) as opposed to two in the twentieth (Europe and North America) and one before that (Europe). . . .

Western thinkers are having a considerable difficulty finding the paradigm to describe a world where non-Western powers are emerging. Their natural impulse is to assume that, as they succeed, these powers would become more like Western societies (an assumption implicit in the 'end of history' thesis) or that there will be a 'clash of civilizations.' Neither is likely. *The difficulty that Western minds face in grasping the arrival of East Asia arises from the fact that we are witnessing an unprecedented historical phenomenon: a fusion of Western and East Asian cultures in the Pacific regions. It is this fusion, not a renaissance of ancient Asian glories, that explains the explosive growth of the Pacific . . .*¹⁷

The context for innovation, and the success at innovation in the next fifty years, will depend in large part upon who understands this change the best. The Japanese or the rest of the world.

¹⁷ Mahbubani, *supra* note 4, at 100.

D. Conclusion

Like the king's son in Edward Sill's poem, are we in the United States and Canada alert to opportunity? Are the United States and Canada willing to really engage in competition with Japan? Are we willing to recognize that innovation is being driven in large part, and will be driven, by the need to balance the resources and energy of Asia and Japan with the capital and freedoms of the West?

Nietzsche tells us in *Beyond Good and Evil* that it is "certainly not the least charm of a theory that it is refutable." These are just a few ideas from a distant observer. I hope that you have found them interesting.

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Appendix A

*Some of the World's Great Inventions*¹⁸

A. *Earliest (9000 B.C.-500 B.C.)*

Spinning	Near East
Copper Smelting	Near East
Wheel	Near East

¹⁸ Encyclopedia Britannica, *Inventions* (1960).

Dyes	Near East
Pulley	Near East
Calendar	Near East
Glass	Near East

B. Classical World (400 B.C.-200 A.D.)

Lead Pipes	Rome
Arched Bridges	Etruria
Gears	Greece
Glass Blowing	Egypt
Piston Cylinder Pumps	Italy
Screw Press	Greece
Carpenter's Plane	Italy
Paper	China

C. Middle Ages (300 A.D.-1500 A.D.)

Soap	Northwest Europe
Porcelain	China
Horseshoe/Horse Collar	Central Asia
Crank Handle	Unknown
Crossbow	Europe
Sea Rudder	China
Gunpowder	China
Magnetic Compass	China
Alcohol Distillation	Europe
Spinning Wheel	Germany
Firearms	China
Spectacles	Italy
Paddle Boat	Italy
Mechanical Clock	Italy
Oil Painting	Italy
Crank and Connecting Rod	Italy
Printing	China/Germany
Suction Pump	Germany
Ventilating Fan	Germany

D. Renaissance (1500-1700)

Screw Cutting Machine	Italy
Telescope	Italy
Water Closet	England
Thermoscope	Italy
Barometer	Italy
Slide Rule	England
Micrometer	England
Adding Machine	France
Pendulum Clock	Italy
Reflecting Telescope	Scotland/England

Lead Glass England

E. *Industrial Revolution (1700-1850)*

Iron Smelting with Coke England
 Marine Chronometer England
 Spinning Machine England
 Cast Steel England
 Spinning Jenny England
 Chlorine Bleach France
 Threshing Machine England
 Cotton Gin United States
 Steam Carriage United States
 Electric Battery Italy
 Gas Light England/France
 Railroad Locomotive England
 Steamboat United States
 Calculating machine England
 Water Turbine France
 Reaping Machine England
 Revolver United States
 Electric Telegraph Germany/England/United States
 Photography France/England
 Electroplating England
 Vulcanized Rubber United States
 Sewing Machine United States

F. *Post-Industrial Revolution (1850-1900)*

Gyroscope France
 Aniline Dye England
 Dynamite Sweden
 Telephone United States
 Phonograph United States
 Filament Lamp England/United States
 Rayon France
 Gasoline Engine Germany
 Linotype Machine United States
 Automobile Germany
 Reinforced Concrete Buildings France/England
 Radio Italy
 Motion Picture Camera France/United States
 Diesel Engine Germany

G. *First Half of the 20th Century (1900-1950)*

Airplane United States
 Triode Electron Tube United States
 Helicopter France
 Plastic United States

Nylon	United States
Electron Microscope	Hungary/Germany
Cyclotron	United States
Radar	England
Television	England/United States
Turbo Jet	Engine England
Xerography	United States
Electronic Computer	United States
Liquid Fuel Rocket	Germany
Chemotherapy	United States
Transistor	United States
Polaroid Camera	United States

*Appendix B¹⁹**Some of China's Great Inventions*

Kite	400 B.C.
Paper	100 A.D.
Porcelain	300 A.D.
Sea Rudder	750 A.D.
Gunpowder	800 A.D.
Foot Treadle	1100 A.D.
Wheelbarrow	1100 A.D.
Magnetic Compass	1100 A.D.
Firearms	1200 A.D.
Printing (Movable Metal Type)	1350 A.D.

¹⁹ *Id.*